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Argue with Science? The Admissability Debate Surrounding DNA Identification

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NOTES

ARGUE WITH SCIENCE? THE ADMISSIBILITY DEBATE SURROUNDING DNA IDENTIFICATION

The utilization of scientific evidence in litigation has increasingly gained acceptance in the courtroom.[1] Examples of evidentiary tools that have been employed include radar,[2] blood testing,[3]

[1] *See, e.g.*, United States v. Sanchez, 829 F.2d 757, 757 (9th Cir. 1987) (permitting identification through use of forward-looking infrared device); Williams v. State, 312 S.E.2d 40, 52 (Ga. 1983) (scientific analysis of fiber evidence played crucial role in murder trial); State v. Wheeler, 496 A.2d 1382, 1386-89 (R.I. 1985) (admitting voice spectrographic identification); *Murder Case, Focus Turns to Science*, N.Y. TIMES, Mar. 26, 1990, at 24 (murder trial focused on scientific evidence consisting of DNA, fingerprint and hair analyses). At least one court found medical evidence sufficient as scientific evidence. *See* State v. Armstrong, 369 S.E.2d 870, 877 (W. Va. 1988) (court found bite-mark evidence sufficiently reliable to allow judicial notice); *see also* RONALD L. CARLSON ET AL., MATERIALS FOR THE STUDY OF EVIDENCE 217 (1983) (noting that it is "virtually impossible" to try major personal injury case without detailed medical evidence and that medical evidence is also becoming necessary in criminal cases).

Before scientific evidence is admitted in a trial, the scientific technique must pass the *Frye* test: general acceptance in its particular field. Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923); *see infra* notes 88-95 and accompanying text (discussing *Frye* test). *See generally* Bert Black, *A Unified Theory of Scientific Evidence*, 56 FORDHAM L. REV. 595, 649-59 (1988) (reviewing admissibility problems of previous and current scientific advances); Paul C. Giannelli, *The Admissibility of Novel Scientific Evidence:* Frye v. United States, *a Half-Century Later*, 80 COLUM. L. REV. 1197, 1200-04 (1980) (discussing early scientific advances and courts' dispositions); Judith M. Gordon, *DNA Identification Test—On the Way Toward Judicial Acceptance*, 6 J. SUFFOLK ACAD. L. 1, 18-22 (1989) (noting New York courts' acceptance of DNA testing as reliable enough to pass *Frye* test).

[2] *See, e.g.*, State v. Gerdes, 191 N.W.2d 428, 431 (Minn. 1971) (extending judicial notice to stationary radar); People v. Knight, 72 N.Y.2d 481, 486, 530 N.E.2d 1273, 1275, 534

and fingerprinting.[4] Since only valid and reliable evidence is useful to the trier of fact, all novel techniques and technologies are necessarily subject to special admissibility hurdles.[5] A current test,

N.Y.S.2d 353, 355 (1988) (accepting validity and reliability of technique underlying moving radar as admissible into evidence); People v. Magri, 3 N.Y.2d 562, 566, 147 N.E.2d 728, 730, 170 N.Y.S.2d 335, 337-38 (1958). In *Magri*, the New York Court of Appeals stated:

> We think the time has come when we may recognize the general reliability of radar speedometer as a device for measuring the speed of a moving vehicle and that it will no longer be necessary to require expert testimony in each case as to the nature, function or scientific principles underlying it . . . . Almost daily, reproductions by photography . . . . , X-rays, electroencephalograms, electrocardiograms, speedometer readings, time by watches and clocks, identity by fingerprinting, and ballistic evidence, among a variety of kindred scientific methods, are freely accepted in our courts for their general reliability, without the necessity of offering expert testimony as to the scientific principles underlying them. The use of radar for speed detection may now be said to fall in this category.

Id. See generally JOHN A. TARANTINO, STRATEGIC USE OF SCIENTIFIC EVIDENCE § 12, at 456-90 (1988 & Supp. 1991) (analyzing scientific evidence, including speed measurement).

[3] *See, e.g.*, Schmerber v. California, 384 U.S. 757, 757 (1966) (upholding constitutionality of taking blood samples and their admission into evidence); Miller v. State, 440 So. 2d 1127, 1129 (Ala. Crim. App. 1983) (admitting blood-grouping evidence in criminal prosecution); State v. Beaty, 762 P.2d 519, 528-29 (Ariz.) (holding blood-grouping tests well recognized and admissible), *cert. denied*, 491 U.S. 910 (1988); Commonwealth v. Gomes, 526 N.E.2d 1270, 1275 (Mass. 1988) (multisystem electrophoresis on dried bloodstain generally accepted in scientific community); .

The Breathalyzer, which measures blood-alcohol content, was recognized by the New York legislature as reliable when it provided that "the court shall admit evidence of the amount of alcohol or drugs in the defendant's blood as shown by a [breathalyzer] test . . . ." N.Y. VEH. & TRAF. § 1195 (McKinney 1986 & Supp. 1992); *see* People v. Donaldson, 36 A.D.2d 37, 40, 319 N.Y.S.2d 172, 176 (4th Dep't 1971). The *Donaldson* court stated that "the Legislature has obviously determined that breath tests, if conducted in accordance with proper procedures, are scientifically reliable for determining the percentage of alcohol in the blood." *Id.*

[4] *See, e.g.*, Moon v. State, 198 P. 288, 290 (Ariz. 1921) (well settled that fingerprinting evidence admissible in criminal cases, weight and value to be determined by jury); People v. Adamson, 165 P.2d 3, 12 (Cal. 1946) (holding fingerprints admissible), *aff'd*, 332 U.S. 46, *reh'g denied*, 332 U.S. 784 (1947); People v. Jennings, 96 N.E. 1077, 1081 (Ill. 1911) (experience has shown fingerprinting to be reliable); People v. Roach, 215 N.Y. 592, 604, 109 N.E. 618, 623 (1915) (noting that, although novel, fingerprint evidence admissible). *See generally* TARANTINO, *supra* note 2, §§ 2.01-2.35 at 49-79 (analyzing scientific evidence, including fingerprints).

[5] *See* Giannelli, *supra* note 1, at 1247. "[N]ovel scientific evidence presents significant reliability problems that may result in erroneous verdicts." *Id.* Professor Giannelli further explains that only reliable evidence contributes to the fact-finding function of a trial, and that reliability depends in part upon the validity of the principle and technique used. *Id.* at 1200-01; *see also* CARLSON, *supra* note 1, at 218. Proponents of expert witnesses should elicit testimony about the validity of the theory and reliability of the instrument. *Id.*; MCCORMICK ON EVIDENCE § 203, at 873 (James W. Strong ed., 4th ed. 1992) (noting that some commentators have suggested substituting validity and reliability test for extent of acceptance test).

DNA profiling,[6] has been the subject of much scrutiny by courts[7] and commentators.[8]

[6] *See, e.g.*, Gordon, *supra* note 1, at 1 ("DNA tests offer a virtually infallible method of identifying a rapist or murderer from trace amounts of biological material left at the scene of the crime."). The scientific technique used to compare and analyze the DNA patterns from two samples has been termed "DNA profiling," "DNA fingerprinting" or "DNA typing" and has been heralded as a "revolutionary forensic technique." Shannon Brownlee, *Courtroom Genetics*, U.S. NEWS & WORLD REPORT, Jan. 27, 1992, at 60; *see* Janet C. Hoeffel, *The Dark Side of DNA Profiling: Unreliable Scientific Evidence Meets the Criminal Defendant*, 42 STAN. L. REV. 465, 465 n.3 (1990) (highlighting different names of DNA testing). *But see* Commonwealth v. Curnin, 565 N.E.2d 440, 441 n.2 (Mass. 1991) (rejecting term "DNA fingerprinting" because it suggests conclusiveness and is therefore misleading).

DNA identification has been applied in both civil and criminal cases with five private laboratories and the Federal Bureau of Investigation's forensic lab providing their services. *See* LIFECODES CORPORATION, INFORMATION PACKET, at DNA Identity Testing Pamphlet 2 (1991) [hereinafter LIFECODES] (available from Lifecodes Corp., Valhalla, NY). Lifecodes Corporation recommends its DNA-PRINT Test for use in the forensic and paternity areas, claiming "[a] minimum paternity probability of 99% for all ethnic groups is ensured!" *Id.* at DNA Paternity Test Pamphlet. For further information on the use of DNA profiling in paternity suits, see generally Aravinda Chakravarti, Ph.D. & Ching Chun Li, Ph.D., *The Effect of Linkage on Paternity Calculations*, *in* 1983 INCLUSION PROBABILITIES IN PARENTAGE TESTING 411, 416-17 (Rene J. Duquesnoy, Ph.D., ed., 1983) (genetic evidence used to exonerate suspect males in paternity dispute); Mary K. Kisthardt, *Of Fatherhood, Families and Fantasy: The Legacy of* Michael H. v. Gerald D., 65 TUL. L. REV. 585, 592 n.60 (1991) (discussing accuracy of DNA testing in establishing paternity); Ronald J. Richards, *DNA Fingerprinting and Paternity Testing*, 22 U.C. DAVIS L. REV. 609, 645-51 (1989) (suggesting use of DNA testing for positive identification in paternity cases).

[7] *See, e.g.*, United States v. Two Bulls, 918 F.2d 56, 58 (8th Cir. 1990) (DNA profiling relatively new and subject of controversy in legal and scientific communities); People v. Castro, 144 Misc. 2d 956, 957, 545 N.Y.S.2d 985, 986 (Sup. Ct. Bronx County 1989). The *Castro* court undertook an extensive investigation into the DNA forensic identification tests during a twelve-week pre-trial hearing which produced a transcript of approximately 5000 pages. *Id.*

Although the previous cases denied admission of DNA typing, several courts have, after considerable analysis, admitted the test results. *See* Andrews v. State, 533 So. 2d 841, 850-51 (Fla. Dist. Ct. App. 1988) (admitted 'genetic fingerprint' evidence based on relevancy test); People v. Wesley, 140 Misc. 2d 306, 332, 533 N.Y.S.2d 643, 659 (Albany County Ct. 1988) (court admitted DNA evidence but reduced probability statistics by power of ten); *see also* State v. Ford, 392 S.E.2d 781, 783 (S.C. 1990) (recognizing reliability of DNA evidence).

Many state courts have admitted DNA evidence upon concluding that it satisfies the general acceptability test of *Frye v. United States*. *See infra* notes 88-95 and accompanying text (discussing *Frye* test); *see also* People v. Shi Fu Huang, 145 Misc. 2d 513, 517, 546 N.Y.S.2d 920, 923 (Nassau County Crim. Term 1989) (DNA profiling meets test of general acceptance); Glover v. State, 787 S.W.2d 544, 548 (Tex. Ct. App. 1990) (DNA admissible because principles, procedures, and technology generally accepted); State v. Woodall, 385 S.E.2d 253, 260 (W.Va. 1989) (DNA admissible because deemed reliable by geneticists and biochemists).

[8] *See* Paul C. Giannelli, *Criminal Discovery, Scientific Evidence, and DNA*, 44 VAND. L. REV. 791, 793 (1991) (standard for admitting novel scientific evidence, including DNA, continues to vex courts); Peter J. Neufeld & Barry C. Scheck, *DNA Testing*, A.B.A. J., Sept. 1990, at 35, 35 (authors contend critical differences between diagnostic and forensic applications

This Note will analyze the admissibility of DNA profiling evidence. Part One will examine the scientific background of DNA "genetic marking,"[9] the procedures currently in use for determining the likelihood of a match between two DNA samples, and the accuracy and reliability of population genetics statistics. Part Two will enumerate the different admissibility standards used in the Eighth and Second Circuits of the United States Court of Appeals. Part Three will consider the rationales of these courts and address whether a judge or jury should decide if proper testing procedures were followed. This question will be examined in light of concerns about possible unfair prejudice to the criminal defendant and evidentiary foundational requirements. Finally, Part Four will discuss how courts might decide this issue in the future, and suggest that a recent New York case provides a viable alternative to the tests adopted in the federal circuits.

I. The Science of DNA Profiling

A. Genetic Background

Deoxyribonucleic acid ("DNA") is the substance in chromosomes[10] which carries the genetic characteristics that make each

of DNA typing exist, that additional techniques must be developed, tested, published in peer-reviewed journals, and debated before accepting technology and admitting novel scientific evidence); William C. Thompson & Simon Ford, *DNA Typing: Acceptance and Weight of the New Genetic Identification Tests*, 75 Va. L. Rev. 45, 46-51 (1989) (noting development of electrophoresis technique); Charles L. Williams, *DNA Fingerprinting: A Revolutionary Technique In Forensic Science and Its Probable Effects on Criminal Evidentiary Law*, 37 Drake L. Rev. 1, 18 (1987-88) (admission of test results into evidence in criminal cases premature). "The consensus discernable from commentators, however, suggests that DNA fingerprinting will eventually be proven reliable and will revolutionize criminal law when admitted into evidence on a regular basis." *Id.*

[9] *See* Paul C. Giannelli & Edward J. Imwinkelried, Scientific Evidence § 17 (1986 & Supp. 1991). 'Genetic markers' refer to serological tests (relating to serums) of blood to determine the race and sex of the source of the blood. *Id.* § 17-8, at 575-76. This testing provides assistance in paternity actions. *Id.* Although genetics refers to the science of heredity, mapping DNA has expanded the potential for genetic marking. *Id.* § 17-8(E), at 603. A gene is a "functional unit of heredity which occupies a specific place or locus on a chromosome, [and] is capable of reproducing itself exactly at each cell division . . . ." Stedman's Medical Dictionary 639 (25th ed. 1990) [hereinafter Stedman's]. *See generally* Randolph N. Jonakait, *Will Blood Tell? Genetic Markers in Criminal Cases*, 31 Emory L.J. 833, 836-43 (1982) (analyzes various blood-grouping tests and their reliability).

[10] *See* Stedman's, *supra* note 9, at 304. A chromosome is "one of the bodies (normally 46 in a man) in the cell nucleus that is the bearer of the genes . . . and is capable of reproduc-

living thing unique.[11] Within the human body, nearly every cell carries an identical DNA configuration.[12] However, except in the case of identical twins, no two individuals have matching DNA configurations.[13] In forensic analysis, this phenomenon is essential for linking the DNA "print" extracted from physical evidence, such as semen,[14] blood,[15] hair,[16] or saliva[17] to a defendant's DNA

ing its physical and chemical structure through successive cell divisions." *Id.*; *see also* K.F. Kelly et al., *Method and Applications of DNA Fingerprinting: A Guide for the Non-Scientist,* 1987 CRIM. L. REV. 105, 105-06. DNA is a human blueprint and is carried in discrete packets of information known as chromosomes. *Id.*

[11] *See, e.g.*, BRUCE ALBERTS ET AL., MOLECULAR BIOLOGY OF THE CELL 5, 98-108 (3d ed. 1983) (describing importance of DNA and complementary pairing of bases for individual characteristics and heredity); Debra Cassens Moss, *DNA—The New Fingerprints,* A.B.A. J., May 1988, at 66, 66 (DNA typing reveals secrets within DNA which carry genetic information dictating such individual characteristics as eye color and body size); *see also* TARANTINO, *supra* note 2, § 13.21B, at 80 ("Each human cell has 46 chromosomes arranged in pairs of 22."); Dan L. Burk, *DNA Identification: Possibilities and Pitfalls Revisited,* 31 JURIMETRICS J. 53, 72-74 (1990) (discussing DNA's value for determining paternity).

The structure of DNA also makes living things similar, for instance, most characteristics between people are the same, such as the number of legs and eyes. *See* Hoeffel, *supra* note 6, at 470 (stating that sequence of base pairs very similar among individuals).

[12] *See* United States v. Jakobetz, 747 F. Supp. 250, 251 (D. Vt. 1990), *aff'd*, 955 F.2d 786 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). For testing purposes, the court emphasized the need for cells containing a nucleus to obtain DNA, since red blood cells do not contain DNA. *Id.* at n.2.

[13] *See* United States v. Young, 754 F. Supp. 739, 740 (D.S.D. 1990) (noting all humans have different DNA structures); *see also* Anthony Pearsall, *DNA Printing: The Unexamined "Witness" in Criminal Trials*, 77 CAL. L. REV. 665, 667 (1989) (discussing background of DNA discovery and relevance for identification purposes except between identical twins).

The fact that DNA structure varies among individuals provides the foundation for DNA fingerprinting. *See* Jeffrey A. Norman, Note, *DNA Fingerprinting: Is it Ready for Trial?*, 45 U. MIAMI L. REV. 243, 243 (1990). Supporters contend that the test "allows for unquestioned identification of evidentiary samples recovered from crime scenes when compared to samples from a defendant." *Id.*

[14] *See* LIFECODES, *supra* note 6, at DNA Identity Testing Pamphlet 2 (suggesting sources of DNA and minimum amounts needed for testing). "Since the DNA in all cells from any individual is the same, DNA from blood can be compared to that from semen, bone marrow, hair root, saliva and solid tissues of the same individual." *Id.* For semen, a sample of 1 to 20 microliters of liquid is necessary. *See id.* at DNA—PRINT Test sheet. *See generally* Alan Giusti et al., *Application of Deoxyribonucleic Acid (DNA) Polymorphisms to the Analysis of DNA Recovered from Sperm,* 31 J. FORENSIC SCI. 409, 413 (1986) (concluding DNA recovered from semen viable for testing).

[15] *See Lifecodes, supra* note 6, at DNA—PRINT Test sheet. Lifecodes suggests 1 to 100 microliters (up to one drop) if in liquid form, or varying from one-half the size of a dime to the size of a quarter for dried blood, would be necessary for determining the DNA configuration from the white cells. *Id.*; Evan Kanter et al., *Analysis of Restriction Fragment Length Polymorphisms in Deoxyribonucleic Acid (DNA) Recovered from Dried Bloodstains,* 31 J. FORENSIC SCI. 403, 407 (1986) (determined DNA typing feasible from dried bloodstains aged up to three years).

[16] *See* Thompson & Ford, *supra* note 8, at 61-62 (DNA found in person's hair follicles

configuration.[18]

The shape of DNA has been identified as a "double helix" structure, which resembles a twisted ladder[19] (see diagram A). Alternating phosphate and deoxyribose sugar units comprise the sides of the ladder, while the connectors or "rungs" of the ladder are composed of pairs of "bases" ("base pairs") known as adenine ("A"), thymine ("T"), guanine ("G"), and cytosine ("C").[20] Depending on its chemical composition, each base will bond only with its complement.[21] The different sequences of the base pairs formulate each person's genetic code.[22] Everyone has these ge-

identical to that in his blood, semen, and other bodily tissues). The consistency of DNA has shown that "DNA found in a man's hair follicles at birth is identical (apart from occasional slight changes called "mutations") to the DNA found in his blood at age seventy." *Id.*; LIFECODES, *supra* note 6, at DNA Identity Testing Pamphlet 2 (sources of DNA include hair root).

[17] *See* LIFECODES, *supra* note 6, at DNA—PRINT Test sheet. The Laboratory recommends 10,000 cells be present in the saliva sample for proper DNA isolations. *Id.*

[18] *See* Moss, *supra* note 11, at 66. Tests have shown that the sample merely needs to be a dried spot of blood about the size of a quarter, a few hairs, a dried spot of semen the size of a nickel, or a small patch of skin tissue. *Id.* Criminal investigators view the testing favorably because it provides many more opportunities for linking a suspect to a crime. *Id.* Along with indicating that DNA from semen taken from a rape victim matches DNA from a suspect's blood sample, the test can determine whether a suspect's DNA matches that of hair left at the crime scene, or from skin scraped by a victim's fingernails. *Id.*

One commentator noted that "[t]he possibility of identifying a human being by a shred of tissue or drop of blood has a strong appeal for its potential to revolutionize rape, paternity, and murder cases." Stephen M. Patton, *DNA Fingerprinting: The* Castro *Case*, 3 HARV. J. L. & TECH. 223, 223 (1990).

[19] *See, e.g.*, JAMES D. WATSON ET AL., MOLECULAR BIOLOGY OF THE GENE 74, 240 (4th ed. 1987) (complementary double helix identified by Doctors Francis Crick and James D. Watson in 1953); *see also* United States v. Jakobetz, 955 F.2d 786, 791 (2d Cir.) (discussing DNA structure), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921).

[20] *See, e.g.*, TARANTINO, *supra* note 2, § 13.21(B), at 80-81 (discussing cellular biology and referring to DNA as ladder structure); Kelly, *supra* note 10, at 106 (providing nontechnical description of DNA structure).

[21] *See* GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(F), at 115 (bases combine together to form base pairs: A always attaches to T, G always attaches to C); *see also* United States v. Jakobetz, 747 F. Supp. 250, 251 (D. Vt. 1990) (order of bases on one side of rung of DNA ladder determines order on other side), *aff'd*, 955 F.2d 786 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); State v. Pennington, 393 S.E.2d 847, 850 (N.C. 1990) (certain nucleotides always pair with one another); Spencer v. Commonwealth, 384 S.E.2d 775, 781 (Va. 1989) (these chemical bases always pair together in certain arrangement), *cert. denied*, 493 U.S. 1036 (1990).

Complementary pairing is crucial for DNA testing because it permits scientists to locate points of differentiation in the DNA chain. *See generally* C. Thomas Blair, Comment, Spencer v. Commonwealth *and Recent Developments in the Admissibility of DNA Fingerprint Evidence*, 76 VA. L. REV. 853, 857 (1990) (summarizing DNA typing process).

[22] *See Jakobetz*, 955 F.2d at 791 (genetic code provides biological instructions to cell); *Spencer*, 384 S.E.2d at 781 (order of nucleotide bases determine genetic code); W. Anthony

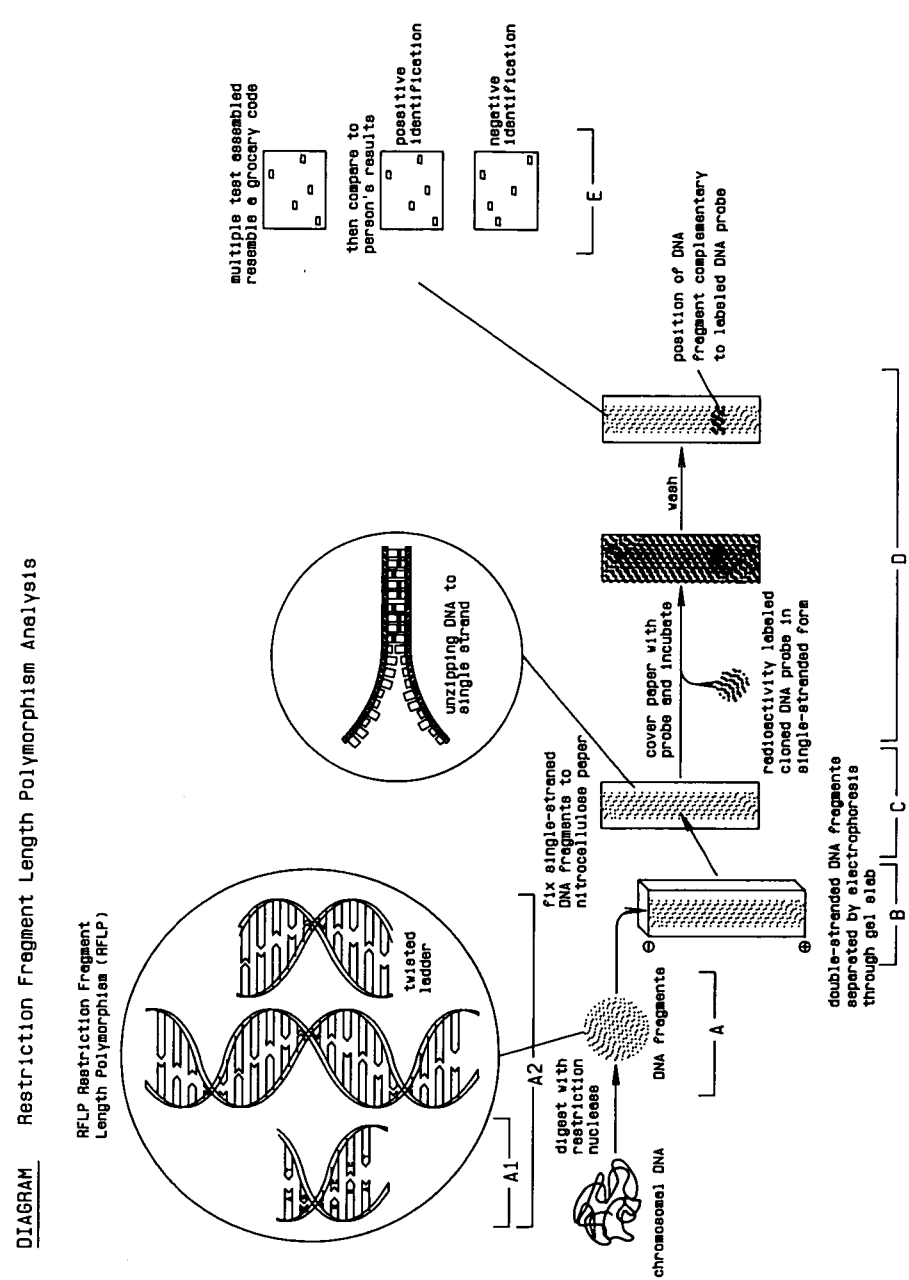
DIAGRAM
Restriction Fragment Length Polymorphism Analysis
RFLP Restriction Fragment Length Polymorphism (RFLP)
twisted ladder
unzipping DNA to single strand
A1
A2
chromosomal DNA
digest with restriction nucleases
DNA fragments
fix single-strand DNA fragments to nitrocellulose paper
A
double-stranded DNA fragments seperated by electrophoresis through gel slab
B
C
D
cover paper with probe and incubate
radioactivity labeled cloned DNA probe in single-stranded form
wash
position of DNA fragment complementary to labeled DNA probe
E
multiple test assembled resemble a grocery code
then compare to person's results
positive identification
negative identification

netic sequences,[23] but they vary from person to person.[24] Advocates of DNA typing contend that these variations, also called polymorphisms,[25] permit an individual to be identified through DNA technologies, since it is extremely unlikely that two individuals share identical polymorphisms.[26] It is suggested that labs analyzing only a fragment of the DNA may reduce the accuracy of DNA profiling because research indicates the possibility that specific groups of individuals may exhibit identical polymorphic genes more frequently than was considered.

Purcell, Comment, *Criminal Procedure—Match Game 1990s: The Admissibility of DNA Profiling*—State v. Pennington, 13 CAMPBELL L. REV. 209, 216 (1991) (order of DNA bases constitutes genetic code of individuals).

[23] *See Jakobetz*, 955 F.2d at 791. Approximately 99% of the DNA in each individual is the same because human beings share more similarities than differences. *Id.*; Lori L. Swafford, Comment, *Admissibility of DNA Genetic Profiling Evidence in Criminal Proceedings: The Case for Caution*, 18 PEPP. L. REV. 123, 124-26 (1990). Human beings have more similarities than differences, thus the vast majority of base pairs do not vary from person to person. *Id.* However, there are certain sections of DNA which vary greatly among individuals. *Id.*

[24] *See Jakobetz*, 955 F.2d at 791 (discussing importance of variations for identification purposes); *see also* People v. Castro, 144 Misc. 2d 956, 962, 545 N.Y.S.2d 985, 988 (Sup. Ct. Bronx County 1989) (small variation in order in which base pairs occur on DNA molecule, known as alleles, provide differences among individuals). The *Castro* court indicated that early uses for DNA tests involved disease detection, and that sickle-cell anemia is caused by a single base pair on a single chromosome occurring out of order. *Id.* at 963, 545 N.Y.S.2d at 989. *See generally* TARANTINO, *supra* note 2, § 13.21(C), at 81 (describing significance of sequence location).

[25] *See* United States v. Young, 754 F. Supp. 739, 740 (D.S.D. 1990). Although as much as 99% of the DNA in every person is identical, certain areas known as polymorphisms are distinct. *Id.* These polymorphisms are responsible for the unique DNA code of each individual. *Id.*; *see also* Swafford, *supra* note 23, at 126 (undisputed distinctiveness is basis for all forms of DNA testing).

[26] *See* State v. Schwartz, 447 N.W.2d 422, 424 (Minn. 1989) ("No two individuals, except for identical twins, have identical DNA."); *see also* Moss, *supra* note 11, at 66. Testing labs claim the DNA test establishes identity conclusively. *Id.* One lab, Cellmark Diagnostics of Germantown, Md., asserts that its "DNA fingerprint" test can identify a individual with "virtual certainty," and that the chances of any two people having the same DNA fingerprint are 1 in 30 billion. *Id.* Lifecodes claims that their research indicates that the likelihood that any two individuals, other than identical twins, having exactly the same polymorphisms in their DNA segments is extremely remote. LIFECODES, *supra* note 6, at DNA Identity Testing Pamphlet 6.

For a general history of the discovery of DNA and its development as a forensic tool, see Edward Burley, *A Study in Scarlet: Criminal DNA Typing Reaches the Courts and Legislatures*, 6 J. L. & POL. 755, 759-766 (1990) (outlining development and process of DNA typing); Leigh C. Lawson, Comment, *DNA Fingerprinting and Its Impact Upon Criminal Law*, 41 MERCER L. REV. 1453, 1454-56 (1990) (same).

B. Restriction Fragment Length Polymorphism Analysis—A Commonly Used Testing Method

The length of each polymorphism is determined by the number of repeat core sequences of base pairs.[27] For example, if A-T is the specified base pair, the length of the polymorphism is the distance between the repeated A-T bonds.[28] The Restriction Fragment Length Polymorphism ("RFLP") technique, employed by the Federal Bureau of Investigation ("FBI"),[29] seeks to isolate the different versions of the RFLP's, also called alleles, to determine whether genetic samples from a crime scene may have come from a particular suspect.[30]

The seven-phase RFLP process can be visualized as chemically "unzipping" the DNA ladder into two single strands of DNA, introducing genetic probes which attach to their complementary strands, and thereby locating the regions of DNA that are

[27] *See Jakobetz*, 955 F.2d at 791. A core sequence is called a Variable Number Tandem Repeat ("VNTR"). *Id.*; *see also* People v. Mohit, 579 N.Y.S.2d 990, 994 (Westchester County Ct. 1992). VNTR's vary in length even though they are sequentially alike in all individuals. *Id.* These VNTR's are highly polymorphic. *Id.*; United States v. Porter, Crim. No. F06277-89, 1991 WL 319015, at *3 (D.C. Super. Ct. Sept. 20, 1991) (discussing polymorphisms).

[28] *See* ALBERTS, *supra* note 11, at 185-94 (discussing method to separate restriction fragments between corresponding base pairs); Hoeffel, *supra* note 6, at 470-71 (variations are polymorphisms).

[29] *See Porter*, 1991 WL 319015, at *3 (FBI uses RFLP technology); United States v. Yee, 134 F.R.D. 161, 169 (N.D. Ohio 1991); *Mohit*, 579 N.Y.S.2d at 994 (FBI uses RFLP analysis to measure and compare VNTR lengths in evidentiary samples); William S. Sessions, Guest Editorial, 34 J. FORENSIC SCI. 1051, 1052 (1989). DNA analysis is used by the FBI to help identify violent criminals earlier in the investigation process, and increases the chances of uncovering the truth. *Id.* "DNA profiling, like a fingerprint, is becoming a scientifically and legally accepted means of positive identification." *Id.*

The DNA typing procedure is performed by six groups, including the FBI and five private laboratories. *See* Comment, *Beyond* People v. Castro: *A New Standard of Admissibility for DNA Fingerprinting*, 7 J. CONTEMP. HEALTH L. & POL'Y 269, 278 n.35 (1991) (providing names and phone numbers of organizations). In addition, some states have expanded the capabilities of their forensic sciences labs to include DNA typing. *See generally* Gordon, *supra* note 1, at 16-18 (discussing laboratories and testing methods).

[30] *See, e.g.*, United States v. Young, 754 F. Supp. 739, 740 (D.S.D. 1990). In *Young*, the RFLP technique was performed by Cellmark Laboratories to determine whether a DNA match existed between samples taken from a sexual assault victim, her aborted fetus, and the defendant. *Id.* The court noted that by the use of these procedures, scientists claim that they now have the ability to determine if two samples of DNA have come from the same individual or, as in *Young*, whether there is a maternal or paternal relationship within the samples. *Id.*; *see* Thompson & Ford, *supra* note 8, at 64. The goal of the RFLP analysis is to identify the polymorphic fragments of the DNA and measure them to determine if they are from identical sources. *Id.*

polymorphic[31] (see diagram A to follow steps of DNA testing). The first step in the process involves obtaining a sample of biological material, like semen, blood, or hair, and *extracting* the DNA through chemical treatment and filtering.[32]

Next, in a process known as *digestion*, an enzyme called restriction endonuclease is introduced to locate the polymorphic regions.[33] The enzyme cleaves the DNA at certain recurring genetic sequences into DNA fragments.[34] The resultant DNA fragments are placed on a thin slab of gel and separated according to length.[35] This is accomplished by *gel electrophoresis*, a procedure which applies an electric current to the gel.[36] Since the DNA has a negative charge, the fragments move toward the positively charged end of the gel.[37] The rate at which the DNA travels is

[31] *See, e.g., Jakobetz*, 955 F.2d at 792 (outlining specific steps of RFLP analysis); *see also* Thompson & Ford, *supra* note 8, at 65 (describing purpose of RFLP test).

[32] *See Young*, 754 F. Supp. at 740-41 (briefly describing RFLP test); *see also* Perry v. State, 586 So. 2d 236, 238 (Ala. Crim. App. 1990) (stating that "[t]he [DNA] test takes approximately three weeks and can be performed accurately from a single strand of hair." (citation omitted)); People v. Shi Fu Huang, 145 Misc. 2d 513, 515, 546 N.Y.S.2d 920, 921 (Nassau County Crim. Term 1989) (extraction and isolation of DNA from evidentiary sample is first step in RFLP process). *See generally* A.J. Jeffreys et al., *Principles and Recent Advances in Human DNA Fingerprinting, in* DNA FINGERPRINTING: APPROACHES AND APPLICATIONS 1 (T. Burke et al. eds., 1991) (review of different DNA tests); LIFECODES, *supra* note 6, at DNA—PRINT Test sheet (providing various biological samples and amounts necessary to conduct tests).

[33] *See* State v. Schwartz, 447 N.W.2d 422, 425 (Minn. 1989) (DNA chain cut at specific sites to form fragment by mixing sample with restriction enzyme); GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(E), at 116. The restriction endonuclease ("RE") enzymes are referred to as "biological scissors" because they cut off a section of the double stranded DNA "ladder". *Id.*

[34] *See* GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(E), at 116. In a properly conducted test, the RE cuts an individual's DNA in the same places every time and therefore produces the same fragments. *Id.* Different individuals have different numbers of base pairs on the fragments cut by the RE. *Id.*

[35] *See* Spencer v. Commonwealth, 384 S.E.2d 775, 781 (Va. 1989) (DNA fragments grouped according to length on sheet of electrically charged gel), *cert. denied*, 493 U.S. 1036 (1990). *See generally* Thompson & Ford, *supra* note 8, at 69-70 (discussing process of gel electrophoresis).

[36] *See Shi Fu Huang*, 145 Misc. 2d at 515, 546 N.Y.S.2d at 921 (discussing process of gel electrophoresis); Jonakait, *supra* note 9, at 838-41 (defining electrophoresis as physical method for separating proteins via electric current); Thompson & Ford, *supra* note 8, at 46-51 (noting development of electrophoresis technique); *see also* Thomas M. Fleming, *Admissibility of DNA Identification Evidence*, 84 A.L.R. 4TH 313, 352-53 (1991) (describing protein gel electrophoresis's effect on accuracy of DNA results).

[37] *See* People v. Castro, 144 Misc. 2d 956, 966, 545 N.Y.S.2d 985, 991 (Sup. Ct. Bronx County 1989). The agarose gel, a "Jell-O"-like substance, is composed of unequally sized holes. *Id.* Thus, the fragments of DNA become trapped, according to their size, as they try

determined by the fragment's size, length, and mass.[38] Because the larger fragments move a shorter distance, the fragments will be arranged according to size, thereby allowing for easier comparison.[39]

Following the denaturation or "unzipping" of the DNA into two complementary strands, the fragments are transferred to a sheet of nylon membrane in a process known as *Southern Blotting*, to provide a more stable medium for analysis.[40] During the next step, *hybridization*, radioactive probes are introduced to locate and bond with particular sequences of the "unzipped" DNA fragments.[41] The radioactive probes hybridize with their complementary restriction fragments on the membrane, and the lengths or sizes of the resulting bands are polymorphic, hence the term "RFLP."[42]

The hybridized array is then exposed to an X-ray film, creating

to reach the end of the gel. *Id.*; *see also* Andrews v. State, 533 So. 2d 841, 848 (Fla. Dist. Ct. App. 1988) (negatively charged DNA moves toward positive charge).

[38] *See* Cobey v. Maryland, 559 A.D.2d 391, 396 (Md. Ct. Spec. App. 1989). The distance the fragments travel depends on their length. *Id.* The longer, bulkier fragments have a more difficult time moving through the gel than the shorter fragments. *Id.*; Pearsall, *supra* note 13, at 673 n.40 (explaining separation of molecules by size and weight in electrophoresis); Sally E. Renskers, Comment, *Trial by Certainty: Implications of Genetic "DNA Fingerprints"*, 39 EMORY L.J. 309, 312-13 (1990) (applying electric charge to gel in electrophoresis sorts out DNA fragments by size); Ray White & Jean-Marc Lalouel, *Chromosome Mapping with DNA Markers*, SCI. AM., Feb. 1988, at 40, 42 (crediting fragment mobility in electrophoresis to length).

[39] *See* United States v. Yee, 134 F.R.D. 161, 170-71 (N.D. Ohio 1991) (discussing gel electrophoresis); United States v. Young, 754 F. Supp. 739, 741 (D.S.D. 1990) (gel electrophoresis results in arrangement of DNA fragments by size along parallel lines); *Cobey*, 559 A.D.2d at 396 (fragments will be arranged by size).

[40] *See* United States v. Jakobetz, 955 F.2d 786, 792 (2d Cir.) (describing Southern Blotting procedure), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); State v. Pennington, 393 S.E.2d 847, 850 (N.C. 1990) (DNA moved to more permanent surface in procedure called Southern transfer). For history on the scientist after whom this phase is named, see Burley, *supra* note 26, at 772 (highlighting Southern Blotting).

[41] *See Castro*, 144 Misc. 2d at 966-67, 545 N.Y.S.2d at 991. With the DNA ladder separated into a single strand, the probe will locate and bind itself to its fixed complementary strand contained on the membrane, i.e., if probe DNA sequence is ACTG, it will attach to TGAC sequence. *Id.* If there is no such strand, the probe will not bind with anything. *Id.*; *see also* Spencer v. Commonwealth, 384 S.E.2d 775, 782 (Va. 1989) (radioactive probe finds exact complementary base sequence and binds to that location), *cert. denied*, 493 U.S. 1036 (1990).

[42] Interview with Mr. Steven E. Artandi, M.D.-Ph.D. candidate at the College of Physicians and Surgeons, Columbia University, in New York City, N.Y. (July 6, 1992). The authors would like to express their gratitude to Mr. Artandi for his review and comments on the scientific aspects of the article.

black bands which indicate where the radioactive probes attached to the DNA fragments.[43] The result of this process of *autoradiography* resembles a grocery bar code.[44]

Lastly, an *interpretation* is performed, whereby the technician either visually contrasts the patterns, or uses a computer to convert the pattern to a numerical code for comparison.[45] The analyst will conclude that the samples' fragments correlate, that the samples do not come from the same source, or that the results are inconclusive due to sample contamination or other external influence.[46]

C. *Probabilities Estimate*

When two samples are determined to be from the same source, the strength of the DNA evidence depends upon the probability that this pattern of alleles could occur randomly in a specific population group.[47] An extremely small statistical probability may

[43] *See Young*, 754 F. Supp. at 741 (describing autoradiography process); State v. Schwartz, 447 N.W.2d 422, 425 (Minn. 1989) (X-ray used so DNA fragments can be seen).

[44] *See* Cobey v. Maryland, 559 A.D.2d 391, 396 (Md. Ct. Spec. App. 1989). The probes produce dark bands on a white background, an image similar to the bar codes found on food packages in supermarkets. *Id.* This is known as an autoradiography or autorad. *Id.*; Moss, *supra*, note 11, at 69 (providing succinct description of steps involved in RFLP and sample processed film card); *see* LIFECODES, *supra* note 6, at DNA Identity Testing Pamphlet 11-12, Figures 3 & 4 (supplying visual exhibits of bar codes).

[45] *See* TARANTINO, *supra* note 2, § 13.21(C), at 83. The author comments that following the process, the analyst compares the fragment patterns from an unknown sample—the evidence—with a known sample—the suspect's. *Id.* If the samples are identical, the analyst should discover the probe on fragments of the same length in the same pattern. *Id.* This match can be detected visually or through the use of a computer. *Id. See generally* Thompson & Ford, *supra* note 8, at 74-76 (discussing interpretation of DNA print).

[46] *See* People v. Mohit, 579 N.Y.S.2d 990, 994 (Westchester County Ct. 1992) ("In comparing the size of the bands to each other, a match, no match, or inconclusive result is found."); *see also* United States v. Yee, 134 F.R.D. 161, 171 (N.D. Ohio 1991) (describing interpretation of DNA test results). While most discussion of the DNA testing focuses on the positive-identification ability, the results have been used to exculpate innocent parties. *See* Charles-Edward Anderson, *DNA Evidence Questioned*, A.B.A. J., Oct. 1989, at 18, 19 (state declined to prosecute after defendant was exculpated based on DNA results); *see also* Sessions, *supra* note 30, at 1052. When discussing the opening of the FBI's DNA lab, Commissioner Sessions stated that DNA profiling can exculpate the innocent. *Id.* In fact, in 1989, the Governor of Virginia granted a full pardon to a convicted murderer when DNA tests indicated that another person was responsible for the crime. *Id.*

[47] *See, e.g.*, People v. Castro, 144 Misc. 2d 956, 967-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (discussing "Hardy-Weinberg" equilibrium which is premised on independent alleles, and its importance for "matches"); *see also* Gordon, *supra* note 1, at 25-28 (providing analysis of foundation for population genetics); Hoeffel, *supra* note 6, at 474 (commonness of particular DNA profile is determined after match is found). *See generally* M. Lynch, *Analysis of Population Genetic Structure by DNA Fingerprinting, in* DNA FIN-

overwhelm a jury considering whether the defendant was the source of the evidentiary sample.[48] The FBI's "fixed bin" method provides a foundation for an understanding of the probabilities estimate.[49]

This procedure involves population genetics and results in a calculation designed to determine if the match is merely a coincidence.[50] For instance, in one case, the frequency with which the defendant's alleles were calculated to occur in the Caucasian population was one in 300 million.[51] For DNA typing, the FBI estab-

GERPRINTING: APPROACHES AND APPLICATIONS, *supra* note 32, at 113, 120-26 (detailing examination of population genetic parameters and its application to DNA typing).

[48] *See* Commonwealth v. Curnin, 565 N.E.2d 440, 441 (Mass. 1991). Discussing the probabilities estimate, the court reversed a criminal conviction, concluding that there is no demonstrated general acceptance of the process by which Cellmark deduced that 1 Caucasian in 59 million would have the identical DNA components as that from the forensic sample. *Id.* at 442; *see also* Andrews v. State, 533 So. 2d 841, 850 (Fla. Dist. Ct. App. 1988) (jury required to either accept or reject expert testimony concerning DNA evidence because it is highly technical and cannot be observed). This facet of DNA fingerprinting has become the subject of much debate. *See infra* notes 56-87 and accompanying text (discussing reliability of DNA profiling test). For an interesting comment on expert testimony, see Albert J. Slap & Marti Fessenden, *Are Forensic Experts an Endangered Species?*, 36 J. FORENSIC SCI. 714, 718-20 (1991) (advocating continued acceptance of expert testimony while permitting jury to determine witness's credibility).

[49] *See Yee*, 134 F.R.D. at 171 (analyzing FBI fixed-bin method); Prater v. State, 820 S.W.2d 429, 438 (Ark. 1991) (FBI fixed bin analysis technique used to establish estimates of probability). *See generally* Stephen C. Petrovich, Note, *DNA Typing: A Rush to Judgment*, 24 GA. L. REV. 669, 677-79 (1990) ("The population genetics statistic is, thus, the key aspect of the DNA Type."); *Acceptability of DNA Evidence is Question for Court, Not Jury:* People v. Morteza Mohit, *County Court, Judge D. Silverman*, N.Y.L.J., Jan. 28, 1992, at 21 (reporting on FBI studies contained in fixed bin analysis as examined in *Mohit*); *Federal Criminal Procedure Admissibility of DNA Evidence*, N.Y.L.J., Jan. 21, 1992, at 25 (recounting use of fixed bin analysis for determining frequency of allele fragment length in populations in *Jakobetz*).

[50] *See* Thompson & Ford, *supra* note 8, at 80-85 (reviewing probabilities procedure). Noting that the probabilities estimate has come under scrutiny, Thompson and Ford affirm that the estimates may vary greatly depending on the test performed and the genetic probes used for the particular test. *Id.* at 80. (citation omitted). *See generally* Michael J. Dirusso, Note, *DNA "Profiles"—The Problems of Technology Transfer*, 8 N.Y.L. SCH. J. HUM. RTS. 183, 209-214 (1990) (reviewing steps involved in calculation and its implications).

[51] United States v. Jakobetz, 955 F.2d 786, 793 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). For a nontechnical comparative analysis illustrating the impact of the statistics, see Edna S. Epstein, *The Problem with DNA Tests: Cross-Examining the DNA Fingerprint*, 78 ILL. B.J. 392, 405 (1990). This article states:

> Allele patterns are circumstantial evidence to which statistical probabilities are applied. To explain the concept of allele frequencies, let us assume we have the following description of a suspect: wearing a tan trench coat, brown shoes, a green beret, red leather gloves, and riding a horse. The question is, what is the probability that two or more individuals would be similarly attired and so mounted? A great deal may depend on the habits of the community. The attire may be improbable, or it may be a standard uniform.

lishes "bins," based on arbitrarily defined ranges of base pair lengths, for classifying alleles.[52] A data base of allele frequencies was developed from DNA profiles from a targeted group of FBI agents.[53] These profiles permit a calculation for determining the frequency of occurrence for alleles falling within a particular bin.[54] Assuming that the alleles occur randomly, the FBI multiplies the frequencies to arrive at the probability estimate for the forensic sample.[55]

D. Population Statistics

Following location of the polymorphisms and interpretation of the bands on the DNA-print,[56] an analyst must provide the statisti-

Id.

[52] *See Jakobetz*, 955 F.2d at 793 (discussing FBI's fixed bin analysis method); GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(F), at 130-32 (reviewing FBI's fixed bin procedure as it relates to targeted populations); *Federal Court Holds 'DNA Profile' Evidence Admissible in Criminal Trial*, 59 U.S.L.W. 1059, 1059 (Oct. 16, 1990) (relating FBI's use of fixed bin genotype-frequency analysis in *Jakobetz*). *See generally* Thompson & Ford, *supra* note 8, at 62-66 (describing analysis of allele lengths); Laurel Beeler & William R. Wiebe, Comment, *DNA Identification Tests and the Courts*, 63 WASH. L. REV. 903, 908-11 (1988) (analyzing allele fragments according to their various lengths); Norman, *supra* note 13, at 245-47 (applying allele lengths to various populations).

[53] *See Jakobetz*, 955 F.2d at 793. The FBI compiles different data bases for different groups, including Caucasians, Blacks and Hispanics. *Id.* In this situation, the Caucasian data base was developed through blood samples from approximately 225 FBI agents. *Id.*

It should be noted that a data base is constructed to facilitate the *inculpating* aspect of DNA profiling. *See* Patton, *supra* note 17, at 228, 233-36. The author indicates that "[f]or scientific identification evidence to have *exonerating* power, no probabilities are necessary. If two samples exhibit non-matching characteristics, they come from two different sources." *Id.* at 236 (emphasis added).

[54] *See* United States v. Jakobetz, 747 F. Supp. 250, 259 (D. Vt. 1990) (indicating bin approach assists in calculation of allele frequencies), *aff'd*, 955 F.2d 786 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); *see also supra* note 49 (discussing FBI's fixed bin analysis). To counter challenges to probabilities estimates, the government's experts "testified that the FBI's fixed bin analysis is a very conservative estimate of allele frequency that more than compensates for potential errors that might result from limitations in technology, limited sample population data, substructure or linkage disequilibrium, and sampling error." *Jakobetz*, 747 F. Supp. at 259.

[55] *See Jakobetz*, 955 F.2d at 793 (describing FBI's use of "product rule"). This "product rule" is outlined in more depth in Commonwealth v. Curnin, 565 N.E.2d 440, 444 (Mass. 1991). The product rule reflects "the probabilities of the joint occurrence of several statistically independent events." *Id.* In *Curnin*, a population geneticist expert witness raised the concern whether the probability estimates are influenced by the existence of significant substructuring (subgroups) within racial groups. *Id.*

[56] *See* United States v. Young, 754 F. Supp. 739, 741-42 (D.S.D. 1990). The court recognized the potential for "band-shifting" which causes a false reading, but found the RFLP test was reliable when properly performed, and therefore the test passed both the *Frye* and

cal significance of the results.[57] A probability estimate is calculated by determining the frequency of the alleles within a relevant population in order to ultimately calculate the chance that the pattern from the forensic sample was from someone other than the suspect.[58] Individual labs have established sample databases, one each for Caucasians, Blacks and Hispanics, to use when determining the DNA sequence frequencies within the various racial groups.[59] Using the forensic sample, the lab will prepare three or four probes garnering six to eight bands for comparison purposes.[60] When a match is isolated, the lab locates the frequency of its occurrence by referring to the sample database.[61] An analyst, utilizing the "product rule," multiplies together each frequency garnished for

Two Bulls standards for admissibility. *Id.*; *see also* Thompson & Ford, *supra* note 8, at 87-95 (outlining potential difficulties for interpretation of prints, including print variability or "slop"). Additionally, these authors note that forensic samples are subject to abuse because the environmental conditions which the samples encounter can vary significantly and thus they are not the typical clean lab samples. *Id.* at 66. Sample degradation may also affect potential readings. *See* Hoeffel, *supra* note 6, at 483 (degraded DNA samples can produce misleading bands).

The FBI combats these problems, such as band-shifting, through the use of a computer imaging process to reference the bands to molecular weight markers on the autoradiograph. *See Jakobetz*, 955 F.2d at 790. For additional proposals regarding standards of performance for forensic laboratories, see Randolph N. Jonakait, *Forensic Science: The Need For Regulation*, 4 HARV. J. L. & TECH. 109, 166 (1991) (stating that labs need uniformity for reliable results and courts need assistance in judging scientific protocols).

[57] *See, e.g.*, *Jakobetz*, 747 F. Supp. at 253 (discussing frequencies needed from human population genetics). The statistical probability can be considered as follows: With the assertion that the chance of a random match is 1 in 30 million, 30 million people would need to be tested before a match would occur by chance. *See* Kelly, *supra* note 10, at 109. For those mathematically inclined who desire a more in-depth view of population genetics than discussed in this Note, see Lynch, *supra* note 47, at 113 (emphasizing limitations in multilocus DNA fingerprinting studies).

[58] *See* United States v. Yee, 134 F.R.D. 161, 171 (N.D. Ohio 1991) (FBI developed table of allele frequencies, applied sample being tested to this table, and multiplied frequencies using product rule to arrive at probability estimate); *Curnin*, 565 N.E.2d at 443 (Cellmark determines allele by allele its frequency in population in its data base); People v. Castro, 144 Misc. 2d 956, 967-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (population geneticists identify specific allele frequencies).

[59] *See, e.g.*, People v. Mohit, 579 N.Y.S.2d 990, 991 (Westchester County Ct. 1992) (FBI lab provided probability estimates for Caucasian, Black, and Hispanic populations); People v. Wesley, 140 Misc. 2d 306, 327, 533 N.Y.S.2d 643, 656 (Albany County Ct. 1988) (discussing DNA groupings); *see also* GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(E), at 129 (noting that data bases are limited, with Lifecodes's including 2,400 individuals and Cellmark's 10,000 individuals).

[60] *See* Thompson & Ford, *supra* note 8, at 84 (discussing procedure for calculating probability estimate).

[61] *Id.*

each matching band; these frequencies represent the alleles.[62] The validity of this multiplication procedure assumes that each variable included occurs randomly and independently of the others.[63] However, the reliability of this procedure has been challenged by population geneticists claiming that alleles do not occur as independently as previously assumed.[64]

Population genetics posits that for the alleles to occur randomly, they must not be caused by "linkage disequilibrium,"[65] and the relevant racial population must be in the "Hardy-Weinberg equilibrium."[66] Linkage disequilibrium can affect the physical proximity of bands on DNA segments.[67] Population geneticists believe that if portions of one person's alleles are identical to those of another person, it is possible for other identical sets of alleles to link up, resulting in longer pieces of identical DNA in two people.[68] If an analyst tested these portions of the strand, a mistakenly positive identification would follow.[69] However, labs

[62] *See id.* The "product rule" provides as follows: If one band of a match corresponds with an allele found in ten percent of the population and the other allele represents that found in fifty percent of the population, the probability of a coincidental match on both alleles is 0.10 x 0.50 = 0.05, or a five percent probability. *See id.* at 81-82. *See generally* GIANNELLI & IMWINKELRIED. *supra* note 9, § 17-9(A), at 607-09. (reviewing population frequencies).

[63] *See Wesley,* 140 Misc. 2d at 327, 533 N.Y.S.2d at 656 (describing random and independent conditions needed to ensure appropriate probability determination).

[64] *See* Richard C. Lewontin & Daniel L. Hartl, *Population Genetics in a Forensic DNA Typing,* 254 SCIENCE 1745, 1746 (1991). The authors suggest the need for "subpopulation studies already carried out for blood groups and enzymes." *Id.* at 1750; *see also* GIANNELLI & IMWINKELRIED. *supra* note 9, § 17-8(E), at 128-30 (inquiring into existence of subpopulations and effect on estimates); Brownlee, *supra* note 6, at 60-61 (noting challenges to population statistics).

[65] *See* Hoeffel, *supra* note 6, at 491 (suggesting laboratory methods to avoid linkage disequilibrium, nonindependent inheritance of alleles caused by close proximity); Thompson & Ford, *supra* note 8, at 85-86 (defining linkage disequilibrium as nonindependence of bands in DNA prints caused by physical closeness of DNA segments).

[66] *See* People v. Castro, 144 Misc. 2d 956, 968, 545 N.Y.S.2d 985, 992 (Sup. Ct. Bronx County 1989) (indicating allele frequencies must be independent from generation to generation).

[67] *See* Thompson & Ford, *supra* note 8, at 85; *see also* Dirusso, *supra* note 50, at 211 (discussing "Hardy-Weinberg equilibrium" as set forth in *Castro*).

[68] *See* Lewontin & Hartl, *supra* note 64, at 1745-46. The authors indicate that a reduction in "linkage disequilibrium" would cause a particular sequence to be more prevalent in a certain population, thereby limiting the effectiveness of the probability calculation. *Id.* at 1747; *see also* Hoeffel, *supra* note 6, at 490-92 (discussing linkage equilibrium's effect on probability estimate); Thompson & Ford, *supra* note 8, at 84-87 (nonindependence associated with linkage disequilibrium).

[69] *See* Hoeffel, *supra* note 6, at 491-92 (describing Lifecodes's declaration of match that

have diminished this problem by using probes that recognize widely separated loci.[70]

The Hardy-Weinberg equilibrium provides a formula for determining population statistics, premised upon a freely mixing population, to ensure an equal distribution of alleles within the groups.[71] Critics argue that the existence of subpopulations, i.e., breeding within groups from different racial, religious, or geographic backgrounds, calls for the rejection of the current probabilities estimate.[72] Subgroup breeding will cause higher rates of identical DNA fragments, thereby skewing the results from the product rule calculation.[73] Because these subgroups exist, population geneticists maintain that the use of one database for all Caucasians and the use of the product rule to determine an allele's frequency is improper.[74] Furthermore, critics contend that the probabilities of matches among people's DNA fragment sequences[75] are much fewer than proposed by labs because random mixing is less frequent in subgroups, due to the fact that populations tend to engage in "endogamy," or marry within one's

encountered dispute); Thompson & Ford, *supra* note 8, at 81-86 (steps for determining match and associated problems).

[70] *See* Thompson & Ford, *supra* note 8, at 85-86 (discussing recent use of multiple probes).

[71] *See* United States v. Yee, 134 F.R.D. 161, 173 (N.D. Ohio 1991) (adopting FBI procedures for DNA tests). U.S. Magistrate Judge James Carr included in his report the distinction between DNA profiles which are homozygotes (polymorphic form of VNTR produces one band) and heterozygotes (polymorphic form of VNTR produces two bands) as well as the FBI's attempt to use a conservative calculation. *Id.* at 172-73; *see also* People v. Castro, 144 Misc. 2d 956, 968-69, 545 N.Y.S.2d 985, 992-93 (Sup. Ct. Bronx County 1989) (utilizing frequency multiplication formula). *See generally* Hoeffel, *supra* note 6, at 489-92 (reviewing and challenging Hardy-Weinberg assumption).

[72] *See* Lewontin & Hartl, *supra* note 64, at 1749-50 (challenging reliability of probability estimates due to labs' failure to consider subpopulations).

[73] *See id.* Lewontin and Hartl contend that the use of statistical tests for the Hardy-Weinberg equilibrium is misplaced as a means to look for genetic differentiation between subgroups in a population. *Id.* at 1747. *See generally* Gordon, *supra* note 1, at 25-27 (providing history for Hardy-Weinberg and relevancy to population statistics).

[74] *See* United States v. Jakobetz, 747 F. Supp. 250, 260 (D. Vt. 1990) (describing perceived flaws in probability estimates), *aff'd*, 955 F.2d 786 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); *see also* Harlan A. Levy, *DNA: Race, Ethnicity and Statistical Evidence*, N.Y.L.J., July 15, 1991, at 1 (critics maintain population statistics based on broad population groupings are useless since there are racial and ethnic subgroups [the technical term used is "substructures"] within the Caucasian, African-American and Hispanic populations).

[75] *See supra* notes 27-30 and accompanying text (identifying VNTR, core sequence pattern of fragment length, and how it relates to DNA profiling).

group.[76] Additionally, critics maintain that the estimates may be misleading by "two or more orders of magnitude" because they ignore the existence of subgroups, thereby reducing the probability of identification to less determinative numbers.[77] Therefore, they suggest that the estimates be excluded from courtrooms until proper subpopulation studies can be performed.[78]

Contrary to this claim, supporters of DNA typing stress that the probabilities are "valid estimates" and possible errors will more frequently balance out than strengthen the estimate.[79] Additionally, two scientists reported that a five-locus DNA profile would have a "vanishingly small" probability of a match, even when accounting for subpopulations.[80] In response to this dispute, the FBI will examine additional DNA databases of ethnic subgroups,[81] while others call for a national DNA database similar to that for fingerprints.[82]

[76] *See* United States v. Yee, 134 F.R.D. 161, 181-82, 184-85 (N.D. Ohio 1991) (testimony involving effect of endogamy); *see also* Lewontin & Hartl, *supra* note 64, at 1747-48 (criticizing use of estimates without proper research).

[77] Lewontin & Hartl, *supra* note 64, at 1749. The census designation "Hispanic" is a biological hodgepodge including Mexicans, Puerto Ricans, Guatemalans, Cubans, Spanish and others. *Id. See generally* John Brookfield, *Law and Probabilities,* 355 NATURE 207, 207-08 (1992) (analyzing dispute in authority regarding population probabilities).

[78] *See Yee,* 134 F.R.D. at 182 (expert witness noting that using FBI's databases would not enable him to make accurate probability statement); *see also* Lewontin & Hartl, *supra* note 64, at 1750 (current calculations unjustified and generally unreliable).

[79] Ranajit Chakraborty & Kenneth K. Kidd, *The Utility of DNA Typing in Forensic Work,* 254 SCIENCE 1735, 1738 (1991). Dr. Kidd claims that the effect of subpopulations is minimal, noting "[i]t makes absolutely no difference . . . if the number is 1 in 800,000 or 1 in 5 million." *Id.*; *see* Leslie Roberts, *Fight Erupts over DNA Fingerprinting,* 254 SCIENCE 1721, 1721 (1991). Dr. Kidd also indicates that "it probably doesn't matter to a jury either." *Id.*

[80] Neil J. Risch & B. Devlin, *On the Probability of Matching DNA Fingerprints,* 255 SCIENCE 717, 720 (1992).

[81] *See* Christopher Anderson, *DNA Fingerprinting—FBI Gives In On Genetics,* 355 NATURE 663 (1992). Announcing that the FBI will undertake investigation of additional subpopulations, John Hicks, the assistant director of the FBI's laboratory division stated, "we want to see if there is any great divergence from the kind of distribution of [DNA] alleles we see in the United States. We've assumed that there isn't." *Id.*

[82] *See* GIANNELLI & IMWINKELRIED, *supra* note 9, § 17-8(E), at 131 (indicating several states mandate all newly convicted felons such as sex offenders to supply samples for DNA databases (citation omitted)). *See generally* Jones v. Murray, 763 F. Supp. 842, 851 (W.D. Va. 1991) (upholding constitutionality of Virginia statute directing creation of DNA database of convicted felons); Joanne Marie Longobardi, *DNA Fingerprinting and the Need For a National Data Base,* 17 FORDHAM URB. L.J. 323, 350-57 (1989) (discussing privacy issues and supporting formation of national DNA database).

The reliability of the probabilities estimate portion of the DNA profiling test has received a mixed response in the courtroom. Population geneticists who challenged this test[83] served to amplify concerns by some courts considering the admissibility of this scientific evidence.[84] Of primary concern is whether a minuscule probability estimate would have an unduly prejudicial effect on a jury's decision-making.[85] For instance, a finding that the likeli-

[83] *See* Lewontin & Hartl, *supra* note 64, at 1745 (questioning assumptions underlying population groups). The authors maintain that forensic scientists ignore considerable evidence indicating genetic substructure within ethnic populations. *Id.* at 1746. Further, they assert "[a]s currently calculated, the estimates may be in error, possibly by two or more orders of magnitude." *Id.* at 1749; *see also* Brownlee, *supra* note 6, at 60 (remarking on prejudicial dangers including falsely implicating suspects). *See generally* Harlan A. Levy, *DNA Evidence in Criminal Cases: Legal Developments*, N.Y.L.J., Apr. 25, 1990, at 1 (anticipating population statistic controversy).

[84] *See, e.g.*, State v. Pennell, 584 A.2d 513 (Del. Super. Ct. 1989). In *Pennell*, the court considered the defendant's motion *in limine* to excluded DNA evidence. *Id.* at 514. Applying the more relaxed Uniform Rules of Evidence standard rather than the *Frye* approach, Judge Gebelein limited the DNA evidence by excluding the statistical probabilities. *Id.* at 519-20. The court noted the probabilities were not reliable, and prejudicial dangers outweighed the probative value of approximate figures derived from calculations based on populations not proven to be in Hardy-Weinberg equilibrium and not corrected in a scientifically accepted way. *Id.* at 519-20; *cf.* Martinez v. State, 549 So. 2d 694 (Fla. Dist. Ct. App. 1989). In *Martinez*, the defendant argued that the expert's testimony concerning the probabilities was so overwhelming that it would interfere with the jury's fact-finding function. *Id.* Finding the mathematical theory for DNA akin to traditional fingerprint evidence, Judge Sharp rejected the defendant's approach and admitted the evidence based on its relevancy and probativeness. *Id.* at 697. Determining the statistical probability to be reliable and admissible, the court indicated that statistical evidence does not prevent the jury from considering the issue of identity because the jury may choose to disbelieve expert witness testimony. *Id. See generally* Caroline M. Kelly, Comment, *Admissibility of DNA Evidence: Perfecting the "Search for Truth,"* 25 WAKE FOREST L. REV. 591, 615-16 (1990) (advocating strict standard for admissibility and standardization of testing procedures).

[85] *See* United States v. Jakobetz, 955 F.2d 786, 789 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). The court recognized how "devastating" the probability estimate can be, noting that: "the results of such testing can be so dramatic as to become virtually dispositive on the question of identity, which often determines a defendant's guilt or innocence." *Id.* The *Jakobetz* court eventually affirmed the defendant's conviction because it believed that a jury was capable of remaining impartial before being convinced by the totality of the evidence presented. *Id.* at 792-93.

The use of the estimate gives the appearance of certainty and reliability which may sway a juror. *See* Moss, *supra* note 11, at 70. Edward Blake of Forensic Science Associates, which uses polymerase chain reaction (PCR) analysis, not RFLP testing, claims he expects DNA typing to become widely used—to the extent that the jury will have little to decide. *Id.* This type of undue reliance on the estimates persuaded some commentators to advocate the more stringent admissibility requirements. *See, e.g.*, Edward J. Imwinkelried, *The Debate in the DNA Cases Over the Foundation for the Admission of Scientific Evidence: The Importance of Human Error as a Cause of Forensic Misanalysis*, 69 WASH. U. L.Q. 19, 46 (1991) (recommending heightened standard of admissibility for scientific evidence).

hood of a specific DNA print randomly occurring in the population is one in 234 billion appears conclusive,[86] especially in light of the fact the earth's population is approximately five billion. Further, the jury may be swayed by these high probabilities that may not be accurate due to ignored subgroups and the practice of fractional testing.[87]

II. Legal Standards for Admissibility

A. Frye v. United States

The landmark case regarding the admissibility of novel scientific evidence is *Frye v. United States.*[88] In *Frye,* the United States Court of Appeals for the District of Columbia held that before evidence deduced from a scientific principle or discovery is admissible, such scientific principle or discovery must have gained "*general acceptance in the particular field* in which it belongs."[89] Although *Frye* cited neither precedent nor authority, its "general acceptance" standard was adopted by a large majority of state and federal jurisdictions.[90] The *Frye* case itself dealt with a systolic

[86] *See Martinez,* 549 So. 2d at 695, 697 (rejecting defendant's challenge that probability estimate was unduly prejudicial, but noting that defense counsel failed to refute underlying scientific basis of test or Hardy-Weinberg equilibrium formula).

An opponent of the estimate figures insisted that a jury cannot prevent being overwhelmed "[w]hen an expert comes in and says there's a one in 700 million chance that your man is not the one—and you know he's only one of 30 million black men in the country—it just kills you. It intimidates the jury." Gary Taylor, *From One Speck, A Case Is Made,* Nat'l. L.J., Jan. 16, 1989, at 3. *See generally* Charity L. Clayborn, Note, *Evidence of DNA Fingerprints Admitted For Identification Purposes in Rape Trial,* 12 U. Ark. Little Rock L.J. 543, 551-56 (1990) (discussing standards of DNA testing followed by courts and suggesting uniform standards).

[87] *See supra* notes 64 & 72 and accompanying text (discussing fractional DNA testing and subgrouping's reducing accuracy of DNA profiling).

[88] 293 F. 1013 (D.C. Cir. 1923).

[89] *Id.* at 1014 (emphasis added).

[90] *See* United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.) (majority of jurisdictions which faced similar issues adopted *Frye* test, and it remains majority rule), *cert. denied,* 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); Carlson. *supra* note 1, at 220 (for most jurisdictions, *Frye* still respected precedent); Hoeffel, *supra* note 6, at 496 (confirming majority of jurisdictions accept *Frye* standard).

For federal decisions applying *Frye,* see, e.g., United States v. Distler, 671 F.2d 954, 961 (6th Cir.) (utilizing *Frye* as operative standard), *cert. denied,* 454 U.S. 827 (1981); United States v. Tranowski, 659 F.2d 750, 756 (7th Cir. 1981) (rejecting evidence as not having gained general acceptance in its field); United States v. Hendershot, 614 F.2d 648, 654 (9th Cir. 1978) (rejecting contention that technology for lifting shoe prints was not generally accepted by crime lab technicians).

blood pressure deception test, an early version of the lie detector.[91] The standard it advocated has since been applied to a wealth of scientific and technical advances.[92] Many such advances, including polygraphy[93] and voice spectrography,[94] have been excluded from evidence for failure to meet the "general acceptability" standard.[95]

For state cases applying *Frye*, see, e.g., State *ex rel.* Collins v. Superior Court, 644 P.2d 1266, 1285 (Ariz. 1982) (*Frye* applicable to hypnotically induced recall testimony); People v. Gonzales, 329 N.W.2d 743, 745 (Mich. 1982) (declaring *Frye* is applicable test in Michigan courts); Commonwealth v. Topa, 369 A.2d 1277, 1281 (Pa. 1977) (spectrographic analysis not sufficiently accepted by scientific community to satisfy *Frye*). *See generally* GIANNELLI & IMWINKELRIED, *supra* note 9, § 1-5, at nn.42-55 (listing state and federal cases that have adopted *Frye* as governing test).

[91] *See Frye*, 293 F. at 1014 (utterance of falsehood requires conscious effort which is reflected in blood pressure).

[92] *See* MCCORMICK, *supra* note 5, § 203, at 869-70.

> Polygraphy, graphology, hypnotic and drug induced testimony, voice stress analysis, voice spectrograms, ion microprobe mass spectroscopy, infrared sensing of aircraft, retesting of breath samples for alcohol content, psychological profiles of battered women, and child abusers, post-traumatic stress disorder as indicating rape, astronomical calculations, and blood group typing, all have fallen prey to . . . [*Frye's*] influence.

Id. at 606 (footnotes omitted); *see also* United States v. Brown, 557 F.2d 541, 557 (6th Cir. 1977) (ion microprobic analysis for hair comparisons excluded because not generally accepted). *See generally* CARLSON, *supra* note 1, at 237-41 (setting forth admissibility of scientific evidence per *Frye*); GIANNELLI & IMWINKELRIED, *supra* note 9, § 1-5(A-D) at 15-25 (discussing *Frye* standard for admissibility of expert testimony on scientific evidence).

[93] *See* GIANNELLI & IMWINKELRIED, *supra* note 9, § 8-2, at 232-48. The authors discuss the commonly accepted theory underlying polygraphy that when a person being examined fears detection, his deceptive response produces measurable physiological reaction. *Id.* The physiological responses examined include changes in blood pressure, pulse, respiration and galvanic skin resistance. *Id.*

[94] *See id.* § 10-2, at 310-18. Voice spectrography involves a speech sample entered into a device called a spectrograph, which converts sounds into a visual display known as a spectrogram. *Id.* at 312. An examiner may then compare different spectrograms to determine if they were made by the same speaker. *Id.*

[95] *See, e.g.*, Brown v. Darcey, 783 F.2d 1389, 1391, 1394-97 (9th Cir. 1986) (excluding polygraphic evidence from trial for failure to meet *Frye*); United States v. Alexander, 526 F.2d 161, 166 (8th Cir. 1975) (same). For cases excluding spectrography evidence, see United States v. McDaniel, 538 F.2d 408, 413 (D.C. Cir. 1976) (finding spectrographic evidence inadmissible because not generally accepted); United States v. Addison, 498 F.2d 741, 745 (D.C. Cir. 1974) (excluding expert testimony of spectrographic voice analysis because not generally accepted). *See generally* MCCORMICK, *supra* note 5, §§ 206(B), 207, at 907-35 (discussing exclusion of polygraphy and voice spectrography from evidence under *Frye* and other standards of admissibility). *But see* United States v. Smith, 869 F.2d 348, 351 (1989) (allowing admissibility of spectrographic voice identification); McMorris v. Israel, 643 F.2d 458, 462 nn.9-11 (7th Cir. 1981) (admitting polygraph results into evidence at trial), *cert. denied*, 455 U.S. 967 (1982); United States v. Webster, 639 F.2d 174, 186 (4th Cir.) (upholding exclusion but noting that district judge had discretion to admit polygraph evidence), *cert. denied*, 454 U.S. 857 (1981); United States v. Williams, 583 F.2d 1194,

In recent years, the *Frye* standard has come under attack by courts and commentators alike, who have expressed dissatisfaction with its ability to adequately determine the admissibility of many modern techniques.[96] DNA profiling is one such technique.[97] The United States Court of Appeals for the Second and Eighth Circuits have been the only two federal appellate courts to address this issue.[98] Neither court expressed wholehearted acceptance of the *Frye* standard; rather each enumerated what was perceived as a more viable solution to the evidentiary problem.[99] The Eighth

1198-1201 (2d Cir. 1978) (admitting spectrographic evidence under *Frye*), *cert. denied*, 439 U.S. 1117 (1979); United States v. Oliver, 525 F.2d 731, 737 (8th Cir. 1975) (allowing admission of polygraph testimony if parties so stipulated), *cert. denied*, 424 U.S. 973 (1976); Commonwealth v. Lykus, 327 N.E.2d 671, 678 (Mass. 1975) (totality of evidence supporting conclusion of general acceptability).

[96] *See* United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921). "[T]he *Frye* test . . . has been attacked for its overly conservative approach to admissibility and its susceptibility to manipulation in order to exclude novel scientific evidence." *Id.*; Giannelli, *supra* note 1, at 1250. "The *Frye* test, which has cast its shadow over the admissibility of scientific evidence for more than a half-century, has proved unworkable." *Id.* Professor Giannelli includes in his criticism of *Frye* the difficulty in identifying the proper scientific field. *Id.* at 1208. Also, although courts do not require unanimous acceptance, there is a broad range of what may constitute "general" acceptance. *Id.* at 1210. Further, *Frye* may cause a "cultural lag" where it will take a long time for even properly admissible techniques to be caught up with in the scientific community. *Id.* at 1223; Mark McCormick, *Scientific Evidence: Defining a New Approach to Admissibility*, 67 IOWA L. REV. 879, 883 (1982) (*Frye* standard has been criticized, limited, modified, and faces increasing rejection). McCormick further states that the adoption of new rules of evidence has caused critical examination of the *Frye* standard. *Id.* at 887; *see also Williams*, 583 F.2d at 1198 ("determination of reliability cannot rest solely on a process of 'counting (scientific) noses' "); United States v. Baller, 519 F.2d 463, 466 (4th Cir.) (without expressly rejecting *Frye*, applied relevancy analysis), *cert. denied*, 423 U.S. 1019 (1975); Joseph G. Petrosinelli, Note, *The Admissibility of DNA Typing: A New Methodology*, 79 GEO. L.J. 313, 317-18 (1990). "The general and imprecise language of the *Frye* test has generated debate over the test's actual requirements." *Id.* at 318. Four concerns have been raised, namely, what is general acceptance, what is capable of general acceptance, who determines the reliability of the evidence, and when the test is applied. *Id.*

[97] *See* Andrews v. State, 533 So. 2d 841, 850 (Fla. Dist. Ct. App. 1988) (discussing DNA test as novel scientific evidence). The Florida District Court of Appeals became the first court in the United States to use DNA evidence in support of a conviction. Nancy Slater, Current Issue, *DNA Fingerprinting: Dick Tracy of the '90s*, 4 ST. JOHN'S J. LEGAL COMMENT. 183, 196 (1989); *infra* notes 102-125 and accompanying text (illustrating current split of authority in circuit courts).

[98] *See Jakobetz*, 955 F.2d at 795 (noting that Eighth Circuit was only other federal circuit court to address issue).

[99] *See id.* at 794 (holding *Frye* standard had previously been superseded by Federal Rules of Evidence); United States v. Two Bulls, 918 F.2d 56, 60 (8th Cir. 1990) (court must satisfy itself that sufficient foundational basis exists before admitting DNA evidence which is potentially unduly prejudicial to defendant); *infra* notes 102-125 and accompanying text (describing DNA admissibility standards used by courts).

Circuit adopted *Frye* but added an additional restriction to admissibility.[100] The Second Circuit embraced an approach less restrictive than the *Frye* test and, therefore, was more receptive to DNA profiling evidence.[101]

B. Eighth Circuit: United States v. Two Bulls

In *United States v. Two Bulls*,[102] the court, in an opinion by Chief Judge Lay, adopted the same standard proposed in *People v. Castro*,[103] which advocated an admissibility test more stringent than the *Frye* test.[104] The *Castro* approach requires a three-prong examination of novel scientific evidence to determine admissibility.[105] Applying this test to DNA profiling, the courts must first determine whether there is a generally accepted theory in the scientific community which finds DNA testing results reliable.[106] Second, it must decide if there are techniques, generally accepted in the scientific community, that are capable of producing reliable results in DNA identification.[107] These first two elements are essentially the equivalent of the *Frye* test.[108] However, the *Castro* and *Two*

[100] *See Two Bulls*, 918 F.2d at 60 (mandatory pretrial hearing held to determine whether particular laboratory which performed test used accepted techniques).

[101] *See Jakobetz*, 955 F.2d at 794 (in attacking *Frye* for its overly conservative approach, court adopted Federal Rules of Evidence approach which is more permissive in determining admissibility).

[102] 918 F.2d 56 (8th Cir. 1990). In *Two Bulls*, a 14-year-old girl was raped on an Indian Reservation in South Dakota. *Id.* at 57. The semen stain found on the victim's underwear was tested against a sample of blood taken from the defendant, Two Bulls, and indicated a match. *Id.* Based on Native American population figures, experts testified that the statistical probability that the stain could have come from someone other than Two Bulls was 1 in 177,000. *Id.* at n.2. The United States Court of Appeals for the Eighth Circuit held that the standard for admissibility used at trial was improper, vacated the conviction, and remanded the case. *Id.* at 61. The court found that the propriety of the labs' testing procedures must be considered in determining the admissibility of the DNA evidence. *Id.*

[103] 144 Misc. 2d 956, 545 N.Y.S.2d 985 (Sup. Ct. Bronx County 1989); *see Two Bulls*, 918 F.2d at 60 (court accepted three-prong test put forth in *Castro*).

[104] *Castro*, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987.

[105] *Id.* at 959, 545 N.Y.S.2d at 987; *see* United States v. Medina, 749 F. Supp. 59, 62 (E.D.N.Y. 1990) (in admitting novel scientific evidence, court should determine that same was obtained properly, laboratory technique was sound, and laboratory was accurate in use of technique); United States v. Young, 745 F. Supp. 739, 741 (D.S.D. 1990) (utilizing test incorporating three prongs of *Castro*); *infra* notes 106-109 and accompanying text (outlining *Castro* test).

[106] *Castro*, 144 Misc. 2d at 959, 545 N.Y.S.2d at 987.

[107] *Id.*

[108] *Compare Castro*, 144 Misc. 2d at 960, 545 N.Y.S.2d at 987 *with* United States v. Frye,

Bulls courts imposed an additional burden on the proponent of DNA evidence in a criminal case.[109] This third element requires the court to determine whether the testing lab properly performed the accepted scientific techniques in analyzing the DNA samples in the particular case.[110] The *Two Bulls* court explained that its test is applicable to other types of novel scientific evidence as well.[111]

C. *Second Circuit:* United States v. Jakobetz

In *United States v. Jakobetz,*[112] the Second Circuit defined the guidelines for determining the admissibility of DNA profiling evidence.[113] In an opinion by Judge Pratt, the court relied heavily on standards implicit in the Federal Rules of Evidence.[114] In particular, the court suggested that the "balancing test" enumerated in Rule 403, which excludes evidence when its probative value is substantially outweighed by the danger of unfair prejudice,[115] coupled with Rule 702, which allows for the testimony of expert wit-

293 F. 1013, 1014 (D.C. Cir. 1923) (stating respective admissibility tests); *see supra* notes 88-95 and accompanying text (discussing *Frye* test).

[109] United States v. Two Bulls, 918 F.2d 56, 60 (8th Cir. 1990); *Castro* 144 Misc. 2d at 959, 545 N.Y.S.2d at 988.

[110] *Two Bulls,* 918 F.2d at 60; *Castro,* 144 Misc. 2d at 959, 545 N.Y.S.2d at 987.

[111] *Two Bulls,* 918 F.2d at 60.

[112] 955 F.2d 786 (2d Cir.), *cert. denied,* 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921).

[113] *Id.* at 789. The facts of the case indicated that a woman travelling on vacation was accosted and kidnapped from a roadside rest area and later raped. *Id.* at 789-90. Telephone records from the rest area pay phones linked Jakobetz to the crime—he phoned his wife immediately prior to a phone call made by the victim. *Id.* at 790. Hair samples that matched the victim's, and other physical evidence tying Jakobetz to the events were discovered in his truck. *Id.* Furthermore, the victim was able to positively identify Jakobetz in a photographic lineup. *Id.* Jakobetz sought to suppress evidence of a DNA profiling study which found that a semen sample from a vaginal swab of the victim was genetically alike in construction to a blood sample taken from him. *Id.* at 789. At trial, experts for the prosecution testified that the probability that the semen sample came from someone other than Jakobetz was 1 in 300 million. *Id.* On appeal, the United States Court of Appeals for the Second Circuit found that the DNA evidence was properly admitted and affirmed the District Court's conviction of Jakobetz. *Id.* at 800, 807.

[114] *Id.* at 795, 796 (citing Rules 403 and 702).

[115] FED. R. EVID. 403. This rule provides that: "[a]lthough relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by considerations of undue delay, waste of time, or needless presentation of cumulative evidence." *Id.*

nesses,[116] should govern the admissibility of this type of evidence.[117] This "relevancy" analysis provides that conclusions which are supported by expert witness testimony should be admitted into evidence unless the danger of unfairly prejudicing or misleading the jury exists.[118] This test relies on the premise that the Federal Rules of Evidence supersede the *Frye* test,[119] as was found in *United States v. Williams.*[120]

In *Williams,* Chief Judge Markey suggested that the probativeness, materiality and reliability of evidence must outweigh any tendency it may have to mislead, prejudice or confuse a jury.[121] The *Williams* court went on to enumerate five suggested determinants of reliability: the potential rate of error, the existence and maintenance of standard testing procedures, the care and concern with which the technique has been employed, the ability to analogize evidence in question to other forms of evidence which are generally admitted, and the demonstration of the test's failsafe characteristics.[122] Once these factors are satisfied, the court may

[116] FED. R. EVID. 702. This rule provides that: "[i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise." *Id.*

[117] United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921); *see* Stephanie B. Goldberg, *A New Day for DNA?*, A.B.A. J., Apr. 1992, at 84, 84-85 (describing Second Circuit as "relevancy plus" jurisdiction).

[118] *See* MCCORMICK, *supra* note 5, § 203, at 875 (relevant conclusions should be admitted absent clear reasons for exclusion); *cf.* Black, *supra* note 1, at 597. To alleviate the difficulty surrounding the admissibility of scientific evidence, the author proposes a two-pronged relevancy test. *Id.* First, the validity of the reasoning of a conclusion and next, the reliability of that conclusion. *Id.*; Dale A. Nance, *Conditional Relevance Reinterpreted*, 70 B.U. L. REV. 447, 447 (1990). The admissibility of "every piece of evidence offered" hinges on its relevancy. *Id. See generally* FED. R. EVID. 401. This rule provides that: "[r]elevant evidence means evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence." *Id.*

[119] *See* MCCORMICK, *supra* note 5, at 608 (general acceptance in community not suitable for determining admissibility of novel scientific evidence); Petrosinelli, *supra* note 96, at 322 (stating that proponents of relevancy test argue that Federal Rules supersede *Frye*). Some jurisdictions have applied a modified relevancy analysis. *See, e.g.*, United States v. Downing, 753 F.2d 1224, 1235 (3d Cir. 1985) (Federal Rules of Evidence neither incorporate nor repudiate *Frye*); *see also* Petrosinelli, *supra* note 96, at 323 (many of same inquiries would be made under *Frye* and modified relevancy test).

[120] 583 F.2d 1194 (2d Cir. 1978). The *Williams* court discussed standards in determining reliability with respect to spectrography. *Id.* at 1198.

[121] *Id.* at 1198.

[122] *Id.* at 1198-99.

properly apply the test which "boils down to a balancing of the reliability of the evidence against its potential negative impact on the jury."[123] Although *Williams* did not deal specifically with DNA evidence,[124] the *Jakobetz* court adopted its rationale as applying to all forms of novel scientific evidence.[125]

III. Proper Scientific Protocol: Weight or Admissibility?

Should a determination of whether proper scientific protocol was followed in the testing procedures be one of weight for the jury, or one of admissibility for the court? The *Two Bulls* court concluded that a showing of proper scientific protocol was a prerequisite to the admissibility of scientific evidence.[126] In support of its position, the Eighth Circuit advanced the theory that there is an increased possibility of unfair prejudice to a criminal defendant if the determination is left to the jury, since it has been argued that jurors tend to give unwarranted weight to hypertechnical scientific testimony that is outside the realm of their understanding.[127]

Another argument in favor of the position taken by the *Two Bulls* court is that for *all* scientific evidence, a proper foundation

[123] United States v. Jakobetz, 955 F.2d 786, 794 (2d Cir.), *cert. denied*, 61 U.S.L.W. 3257 (U.S. Oct. 5, 1992) (No. 91-7921).

[124] *Williams*, 583 F.2d at 1196. The scientific evidence involved in *Williams* was spectrographic voice analysis. *Id.*

[125] *Jakobetz*, 955 F.2d at 796.

[126] United States v. Two Bulls, 918 F.2d 56, 59 (8th Cir. 1990). "[P]assing muster under *Frye* alone is insufficient to place this type of evidence before a jury without a preliminary critical examination of the actual testing procedures performed in a particular case." *Id.* at 59 (citing People v. Castro, 144 Misc. 2d 956, 960, 545 N.Y.S.2d 985, 987 (Sup. Ct. Bronx County 1989)).

[127] *Id.* at 61; *see Jakobetz*, 955 F.2d at 796 (defendant insisted that jury was unable to independently scrutinize DNA evidence in light of complicated expert testimony and urged that an "aura of mystic infallibility" surrounding evidence led jury to abdicate its fact-finding function, prejudicing his defense). This argument finds further support in the cases and commentaries on this subject. *See* United States v. Baller, 519 F.2d 463, 466 (4th Cir.) (apparent objectivity of scientific testimony may cause jury to give it undue weight), *cert. denied*, 423 U.S. 1019 (1975); United States v. Addison, 498 F.2d 741, 744 (D.C. Cir. 1974). "[S]cientific proof may in some instances assume a posture of mystic infallibility in the eyes of a jury of laymen . . . ." *Id.* at 744; Giannelli & Imwinkelried, *supra* note 9, § 1-6(B), at 33 (principal danger of scientific evidence is its potential to mislead); Hoeffel, *supra* note 6, at 511. Jurors are not likely to second guess the opinions of experts testifying about DNA test results. *Id.* Also, jurors in early DNA cases "were in no position to reject evidence as exciting and as intimidating as DNA typing." *Id.* at 515.

must be laid before it can be admitted.[128] The Eighth Circuit held that the necessary foundation included a demonstration that proper scientific protocol was followed in each particular case.[129] Such a showing should be made at a pre-trial hearing to determine whether or not the jury will be allowed to use the evidence in drawing its conclusions.[130]

However, in the Second Circuit, the *Jakobetz* court believed that whether proper scientific protocol was followed is a determination to be made by the trier of fact, generally the jury.[131] The court found that DNA evidence should not require its own special standard of admissibility and argued that determining whether or not the test was properly conducted was clearly within the province of the jury.[132] Proponents of the relevancy test for determining the admissibility of novel scientific evidence provide support for the Second Circuit's arguments since they believe that all relevant evidence should be admitted absent a clear reason for excluding it.[133] Additionally, as noted in *United States v. Williams,* sufficient inherent procedural safeguards exist to warrant allowing such testimony to reach the jury.[134] The credibility of the expert, the accu-

[128] *See Two Bulls,* 918 F.2d at 60 (proper foundation must be laid for all scientific tests and lab procedures).

[129] *Id.* at 60. "If the court has explored only scientific acceptability and the reliability of acceptable testing procedures in camera, and then, at trial the government fails to show that the lab tests did conform to reliable procedures, the court would have to exclude the evidence for lack of foundation." *Id.* The court further stated that for other types of scientific evidence, including polygraph and blood tests, such a stringent foundational requirement, a showing that correct procedures were followed, has been necessary. *Id.* (citing Sprynczatyk v. General Motors Corp., 771 F.2d 1112, 1122-24 (8th Cir. 1985), *cert. denied,* 475 U.S. 1046 (1986); *see* United States v. Alexander, 526 F.2d 161, 163-64 (8th Cir. 1975) (refusing to admit polygraph test where procedures not generally accepted); *see also* State v. Schwartz, 447 N.W.2d 422, 426 (Minn. 1989) (DNA test results only as reliable and accurate as testing procedures used by particular laboratory); Imwinkelried, *supra* note 85, at 28-29 (use of proper test protocol should be prerequisite to admitting scientific evidence).

[130] *Two Bulls,* 918 F.2d at 60.

[131] *Jakobetz,* 955 F.2d at 796; *cf.* Ellis v. International Playtex, Inc., 745 F.2d 292, 304 (4th Cir. 1984) (experts should debate acceptability of scientific data before jury).

[132] *Jakobetz,* 955 F.2d at 796.

[133] *See* McCORMICK, *supra* note 5, § 203, at 875 (contending jury should consider all relevant evidence); 3 JACK B. WEINSTEIN & MARGARET A. BERGER, WEINSTEIN'S EVIDENCE § 702[03], at 702-30 (1991) (jury intelligent enough, with assistance of counsel, to consider only helpful evidence).

[134] United States v. Williams, 583 F.2d 1194, 1200 (2d Cir. 1978), *cert. denied,* 439 U.S. 1117 (1979).

racy and reliability of his equipment and the technique itself are all subject to challenge and attack on cross-examination and through the testimony of opposing experts.[135] Also, the jury can be instructed that, should it find the testimony unreliable, it may reject it.[136]

Furthermore, rather than proving to the judge prior to the trial that the proper scientific protocol was followed, as was done in the Eighth Circuit,[137] the *Jakobetz* court favored a more relaxed approach to the foundation question.[138] The court stated that scientific data should be admitted only upon a preliminary showing of reliability.[139] Such a showing might include evidence of how the lab work was conducted and what analysis and assumptions underlie the probability calculations.[140] The court found that affidavits regarding the testing procedures used would generally be considered a sufficient foundational basis for admitting DNA profiling evidence.[141] The fact that only a preliminary showing was necessary is consistent with the policies underlying the relevancy test advocated in *Williams*[142] and would allow a jury to retain its fact-finding function.[143]

IV. The Future of DNA Profiling

In determining the standard for admitting DNA profiling evidence, the Eighth and Second Circuits have advocated comprehensive, yet disparate, approaches.[144] Such inconsistent authority

[135] *Id.*

[136] *Id.*

[137] United States v. Two Bulls, 918 F.2d 56, 59 (8th Cir. 1990); *see supra* notes 126-130 and accompanying text (outlining Eighth Circuit's holding regarding laying foundation for evidence).

[138] *See Jakobetz*, 955 F.2d at 800 (factual determination should rarely be excluded from jury).

[139] *Id.*

[140] *Id.*

[141] *Id.*

[142] *Williams*, 583 F.2d at 1198 (*Williams* dealt with question of determining admissibility, not with truth or falsity of scientific "fact" or "truth"); *see* McCormick, *supra* note 5, § 203, at 876. "[T]he rigor of the requisite foundation can be adjusted to suit the nature of the evidence and the context in which it is offered." *Id.* (footnotes omitted); *supra* notes 120-123 and accompanying text (discussing *Williams's* reliability analysis).

[143] *See Jakobetz*, 955 F.2d at 800 (jury must retain fact-finding function despite difficulties in weighing confusing evidence).

[144] *See supra* notes 102-125 and accompanying text (discussing approaches taken in

will necessarily cause federal and state courts facing this issue in the future to adopt either the relevancy test employed in *Jakobetz*,[145] the three-prong analysis favored by *Two Bulls*,[146] or, it is suggested, a different approach likely to combine elements of each.

Recently, in *People v. Mohit*,[147] the Second Judicial Department of New York was called upon to address the admissibility of DNA evidence.[148] There, the court relied on the general acceptability standard of the *Frye* test.[149] The primary focus was whether probability estimates should be considered as a matter of admissibility for the court, or allowed into evidence upon only a preliminary showing to the judge, to be weighed by the jury later.[150] The *Mohit* court held that whether or not the probability estimates were proper was an issue of admissibility.[151] In arriving at its decision, the court rejected the Second Circuit's decision in *Jakobetz* to allow the jury to weigh the propriety of the probability estimates.[152] The court explained that this issue was in part demonstrative of the overall general acceptability, and therefore, an admissibility issue.[153] The *Mohit* court expressly rejected the third prong of the *Two Bulls* analysis, by declaring that whether or not the experiment was properly conducted should be an issue of

Eighth and Second Circuits).

[145] *Jakobetz*, 955 F.2d at 796-97; *see supra* notes 112-125 and accompanying text (discussing approach taken in Second Circuit).

[146] *Two Bulls*, 918 F.2d at 60; *see supra* notes 102-111 and accompanying text (discussing approach taken in Eighth Circuit).

[147] 579 N.Y.S.2d 990 (Westchester County Ct. 1992).

[148] *Id.* at 991. The defendant, Dr. Mohit, was indicted for raping and sexually abusing a patient during an office examination. *Id.* Semen was recovered from a vaginal swab of the victim and was tested along with the defendant's blood to determine the possibility of matching DNA characteristics. *Id.* A match was declared, and it was held that "the probability of such a match occurring in the United States was 1 in 67,000,000 for Caucasians, 1 in 79,000,000 for Blacks, and 1 in 14,000,000 for Hispanics." *Id.* The court held that the DNA evidence was admissible, yet it limited the probability estimates. *Id.* at 999.

[149] *Mohit*, 579 N.Y.S.2d at 991; *see supra* notes 88-95 and accompanying text (discussing *Frye* test).

[150] *Mohit*, 579 N.Y.S.2d at 993. "If . . . a reliable match is made, but the probabilities attached are not reliable, should the proponent of the evidence be denied its admissibility altogether?" *Id.*

[151] *Id.* at 993-94.

[152] *Id.* at 993.

[153] *Id.* at 992.

weight for the jury.[154] In so holding, *Mohit* advocated an approach whereby the court could examine the probability estimates, modify them as necessary, and then submit them to the jury to be weighed for their usefulness and credibility.[155] The court further suggested that the entire issue could be remedied if statutorily acceptable uniform laboratory standards and procedures were developed.[156]

Conclusion

There are a great many concerns that the courts must address in determining the admissibility of DNA profiling evidence. While the Eighth Circuit feared that the leniency of the relevancy approach might cause unfair prejudice to the criminal defendant, the Second Circuit felt that the strictures of the *Two Bulls* approach would keep valuable probative evidence from the jury. It is suggested that the approach taken by the court in *People v. Mohit* would do much to alleviate these fears. The *Mohit* court provides an alternative whereby the traditional roles of judge and jury are left substantially intact. The approach it advocated ensures minimal unfair prejudice to the criminal defendant, while allowing maximum probative use of the currently available technology.

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[154] *Id.* (citing People v. Castro, 144 Misc. 2d. 956, 545 N.Y.S.2d 985 (1989)).

[155] People v. Mohit, 579 N.Y.S.2d 990, 993 (Westchester County Ct. 1992). The court enumerated its own three-step analysis, posing the following questions:

1. Does the laboratory in question utilize procedures or protocols which are generally accepted as reliable within the scientific community (here the relevant scientific community being molecular biologists);
2. Are the principles utilized in the laboratory in calculating the probability of a match generally accepted as reliable within the scientific community (here the relevant scientific community being population geneticists and human geneticists);
3. If the laboratory procedures are acceptable, but the probability estimates are not, is the means of quantifying the probability of a match in a manner which would be generally accepted within the relevant scientific community, even if most would consider the estimate to be too high.

Id.

[156] *Id.*